SEDIMENT TRANSPORT

NAVIGATION AND DREDGING

UGLCCS ACTIVITIES INTEGRATION

COMMITTEE SEDIMENT WORK GROUP

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TABLE 2

DREDGING SOFT SEDIMENTS - HOPPER DREDGE

	Miles of Channel		Square Miles of Channel	
	100%* CW	<100%* CW	100%* CW	<100%* CW
Lake Erie	4.7	NIL	7.4	NIL
Detroit River	2.5	0.7	0.5	0.1
St. Clair River	5.2	4.7	0.7	0.5
St. Mary's River	NIL	NIL	NIL	NIL
TOTAL	12.4	5.4	8.6	0.6

OBSTRUCTION REMOVAL - CRANEBARGE

Lake Erie	25.0	NIL	38.6	NIL
Detroit River	8.5	NIL	1.7	NIL
St. Clair River	NIL	13.1	NIL	1.2
St. Mary's River	2.7	6.9	0.7	0.9
TOTAL	36.2	20.0	41.0	2.1

* CW - Canadian Waters

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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers, North Central Division and Environmental Protection, Ontario Region, Environment Canada focused on Activity Number G.4 Upper Great Lakes Connecting Channels Work Plan titled "Impacts and Significance of Navigation and Dredging on Sediment and Contaminant Redistribution". The study's purpose was to assess the significance of dredging and navigation on the redistribution of sediments and assorted contaminants. The approach used was to assess ongoing and completed study results which evaluated the effects of ship movement and dredging on resuspension and compare these effects to wind and wave induced resuspension. The attempt was also made to assess the significance of dredging and disposal on the mass balance of contaminants as compared to other removal mechanisms. It was expected that this examination would result in an estimate of the significance of navigation and dredging on sediment and contaminant redistribution.

This report is divided into two main sections: Navigation and Dredging. The navigation section focuses on background water quality, available ship passage studies and sedimentation rate studies relative to the Upper Great Lakes Connecting Channels. The dredging section will focus upon dredging as a mechanism for contaminant removal from the Upper Great Lakes Connecting Channel system through a compovison of dredging records with bed load passing out of the system.

Although no definitive statement can be made regarding the effect of ship passage on contaminant redistribution on attempt will be made to demonstrate that natural background water quality is greater than and independent of ship induced variation. No direct correlation could be identified between sediment accumulation and shipping activities. The study will also attempt to demonstrate that dredging plays a relatively insignificant role in the mass transfer of sediment and associated contaminants.

INTRODUCTION

Early in the development of the Upper Great Lakes Connecting Channels Study, the Sediment Work Group agreed to investigate the relative importance of navigation and dredging as processes that effect the mass movement of contaminants in the Upper Great Lakes Connecting Channels. These activities were assumed to have a negligent importance in terms of contaminant dynamics and some relatively simple analyses were performed to test this assumption. Based upon two estimation techniques used by the study group, the relative importance of dredging as a mechanism for removal of sediment from the system is judged to be <1% of the total bed load moving through the connecting channels. Therefore, the contaminants associated with these sediments do not constitute a large fraction of the total contaminants available in the system.

The sediment work group reviewed studies performed by U.S. and Canadian agencies in order to determine the extent and significance of navigation induced sediment resuspension. All available studies suggest that any such effects, if measured at all, are masked by background levels due to natural processes. More detailed discussions will be included under the section dealing with navigation.

For the purpose of this discussion relating to dredging the Work Group decided to focus upon the Detroit River as being the most significant channel in the system. It was felt that any effects and associated impacts identified here would be the most pronounced, especially in terms of the role played by dredging in the mass transfer of sediment and associated contaminants. The other connecting channels do not contribute as important a bed load for contaminant transport.

Navigation

The United States Army Corps of Engineers in its consideration of the extension of operation of the locks at Sault St. Marie undertook a study in 1982 which evaluated past and current water quality data in the connecting waterways. The data was taken in the connecting waterways between Lakes Huron and Erie (the St. Clair and Detroit Rivers and Lake St. Clair). The study was composed of three distinct phases: a) background water quality b) ship passage studies and c) sedimentation rate studies.

It should be understood that no attempt was made to understand the water quality of the system as a whole but rather to concentrate on navigation effects. The study focused upon the influence of a ship passing by a given point and the water quality in the vicinity of that point. The study also characterized the existing background water quality conditions and sediment flux rates at two points in the St. Clair and Detroit Rivers. The intent of the background water quality phase of the project was to look for extreme values of total

suspended solids and turbidity and to compare these values to those caused by ship passages. Other water quality parameters were also examined in on attempt to determine whether ship traffic could have an adverse effect on water quality. Parameters of interest include pH, temperature, turbidity, suspended solids, and dissolved oxygen.

It was found that background water quality has been continually improving at least since 1967. There is significant seasonal variation in temperature and dissolved oxygen not related to shipping activity. Background variation in all parameters studied during this project as reported to the Environmental Protection Agency's STORET system was greater than any observed variation due to ship passages. Although seasonal variation is clearly evident for temperature and dissolved oxygen, no seasonal variation was evident for turbidity, suspended or volatile solids, or pH. It is concluded that natural background variation is greater than and independent of ship induced variation.

During the ship passage phase of the study, data were collected for 42 separate ship passages. Data were anlayzed for relationships between seasons, locations, and parameter correlations. No significant relationships were found. It is concluded that either such relationships do not exist, or as Hodek et al conclude "the temperary turbidity increase from a vessel passage varies little, if any, near the navigation channel...." Since the sampling sites chosen for this study were fixed by possible adverse environmental consequences from extension of the navigation season, it is concluded that such adverse environmental consequences will not occur at those sites. If such concerns exist for other areas, site specific studies should be undertaken at those sites.

Winter sediment accumulation data collected during two winters showed a pattern of increasing rate of accumulation at the head of the Detroit River over both winters. This pattern was also evident but less clearly defined for both stations in the St. Clair River during the one winter data were collected there. In the lower Detroit River, the pattern was reversed at one station and inconclusive at the other. Although some shipping activity occurred at all of these sites during the winter, there is no way to correlate shipping activity with the observed data. Due to the location of the sampling sites, it is believed that observed data represent natural background sediment accumulation. the rate of increase in accumulation toward the end of the winter is believed to be related to the increase in flow of the river rather than shipping activity or ice conditions.

The Great Lakes Fisheries Research Branch (GLFRB) of Fisheries and Oceans Canada (DF)) has studies underway whose objectives are:

1. To assess the bioavailability and toxicity of in-place pollutants, originating from bottom sediments and suspended particulates in the St. Clair, Detroit, and St. Mary's Rivers, to the edible food resource uttraplankton.

2. To assess the significance of navigation on the redistribution of sediment-associated contaminants in the St. Clair, Detroit, and St. Mary's Rivers as described in Activity Number G.4 of the 1985 UGLCCS Work Plan.

Studies completed to date which have focused on the navigational impact on water quality in the connecting channels have not addressed the biological effects of such navigational activities. Consequently, there is a need to assess the impact of such activities on water quality and components of the biota residing in the St. Clair, Detroit and St. Mary's Rivers. The work and experimental outline associated with the navigational impact studies is as follows:

Navigational Impact Studies

An attempt will be made to determine the impact of the passage of ships of various draughts. These experiments will be carried out by monitoring the navigation sites for sediment-associated contaminants before (background) and after the passage of a ship. This will be accomplished by chemical analyses of sediment and water samples as well as by means of Algal Fractionation Bioassays (AFB's, Munawar 1982, Munawar et al 1983). Time series experiments will provide an estimate of the recovery of the ecosystem to the background (control) conditions. Given below are the details of the experimental work:

A. In Situ Primary Productivity

Experiments will be conducted at six sties (two sites in the St. Mary's, St. Clair, and Detroit Rivers respectively). Samples (4 litres each) will be collected along each vessel's proposed course in the docking areas immediately before (maximum 1 hour), immediately after, and up to 2 hours following the vessel's movement (depending on the currents). Each of the four litre samples will be divided in half. The first half will be immediately subsampled for phytoplankton identification and enumeration, water chemistry, chlorophyll a, and primary production analyses. Four 100 ml replicate samples will be incubated with carbon-14 for four hours, after which the samples will be size-fractionated for scintillation counting, in order to estimate primary production under the in situ conditions. Estimations of productivity for the two size fractions, ultraplankton (<20um) and microplankton/netplankton (>20um), will be made.

B. Filtered vs Unfiltered Bioassays

On litre of the second half of the sample will be immediately filtered through 0.45 un Millipore membrane filters, then stored at 4°C for later use together with one litre of unfiltered sample water. The filtered and unfiltered sample water will be subsampled for chemical analyses and used for spiking at 1, 5, 10, and 20 percent concentrations as test material in bioassays with natural phytoplankton or laboratory grown cultures.

C. Sediment-Elutriate Bioassays

In addition, a sediment sample will be collected at each site. These sediments will be subsampled for chemical analyses. An elutriate will be prepared form each sediment, as per the procedures developed in G.L.F.R.B. These elutriates will also be subsampled for chemical analyses. Each elutriate will be tested by A.F.B.'s, as described for the filtered and unfiltered water samples.

Suspended Particulates Collection and Assessment

Three suspended particulate samples will be collected, one from each of the three rivers. The particulates will be collected by high-speed centrifuge (Thomas and Munawar 1985). These suspended ~~sediments will be~~ subsampled for chemical analyses. These sediments will then be assessed as in section C above.

Chemical/Biological Analyses

Phytoplankton identification and enumeration of the two size fractions and the total population will be analyzed according to Munawar et al (1974). Chlorophyll a concentrations will be determined by the procedure of Strickland and Parsons (1968). Carbon-14 uptake will be determined by scintillation counting as per the procedure described in Munaware et al (1983). Chemical analyses of water and sediments will be performed by the Environmental Protection Service (Waste Water Technology Centre) as per the Water Quality Branch procedures (1979).

Dredging

Two different estimating techniques were used to calculate the extent and significance of dredging as a mechanism for removal of sediment from the connecting channels. The U.S. Army Corps of Engineers technique is discussed below.

In order to evaluate the importance of dredging as a mechanism for contaminant removal from the Upper Great lakes Connecting Channels system, dredging records were obtained for the Detroit River and compared with the bedload passing out of the Detroit River System. The Detroit River was selected for analysis because: 1) it has the greatest quantity of material dredged from it on an annual basis; and 2) a literature value for total bedload was available for comparison.

U.S. Army Corps of Engineers dredging records show that over the fourteen year period from 1971 to 1984, inclusive, 5,593,500 cubic yards of sediment was removed from the Detroit River navigation channel (J. Limburg, personal communication), or an average of 399,536 cubic yards per year. Most of this material was dredged from the portion of the navigation channel extending into Lake Erie. For purposes of this analysis, the Detroit River was defined to terminate at Range 3.9. In the ten year period from 1975 to 1985, three dredging operations were conducted where sediment was removed above Range 3.9, totalling 65,100 cubic yards (6,510 cubic yards per year). This represents a small fraction of the material dredged from the entire navigation channel.

Table 1 shows the assumptions used to compare the 6,510 cubic yards dredged annually to the literature value for total suspended solids entering Lake Erie from the Detroit River of 1.4 million metric tons per year (Kemp, et al., 1976). Based upon this analysis, approximately 0.5% of the total suspended sediment passing through the Detroit River each year is removed by dredging of the navigation channel. Because this represents a relatively small output from the system, the contaminants associated with these sediments would similarly represent a small fraction of the total mass of contaminants exiting the Detroit River system. For this reason, the Sediment Work Group felt that no additional investigation or refinement of this analysis was necessary.

Due to the relatively insignificant role dredging plays in the mass transfer of sediment and associated contaminants in the Detroit River system, and the fact that the impact of dredging is greatest in the Detroit River, relative to the St. Mary's River, St. Clair River and Lake St. Clair, it can therefore be assumed that dredging is also a relatively unimportant process in these connecting channels as well.

The second estimating technique uses data generated by the Aids and Waterways Branch of Transport Canada and presents the total linear miles of channel and square miles of channel dredged in Canadian Waters. Based on total area dredged (see Table 2) it can be assumed that dredging is an unimportant process in the connecting channels. No effort was placed into conducting further work relative to assessing dredging as a process for sediment removal in the connecting channels.

Ian Orchard - EP-DOE
David Cowgill - U.S. COE - North Central Division

TABLE 1

CALCULATIONS OF THE SIGNIFICANCE OF DREDGING FOR THE DETROIT RIVER

Assumptions and Approximations:

Dredging amount is expressed in cubic yards
1 cubic yard = 765 litres
Assume dredged material is 50% solids
Therefore, amount solids dredged per cu yd = 383 litres
Assume approximate solids density of 2.5 kg/L
Therefore, amount solids dredged per cu yd = 2.5 kg/L x 383 L
= 960 kg
or approximately 1 metric ton

Thus, 1 cu yd = 1 metric ton solids.

DETROIT RIVER DREDGING ABOVE RANGE 3.9, 1975-1985

Year	Amount Dredged* (metric tons)	Suspended Sediment Load** (metric tons)
1984	0	1,400,000
1983	2,000	1,400,000
1982	5,100	1,400,000
1981	58,000	1,400,000
1980	0	1,400,000
1979	0	1,400,000
1978	0	1,400,000
1977	0	1,400,000
1976	0	1,400,000
1975	0	1,400,000
TOTAL	65,100	14,000,000

So, 65,100 = 0.0046, or approximately 0.5% of total loading 14,000,000

* From U.S. Army Corps of Engineers, Detroit District dredging records provided by Ms. J. Limburg.

** Suspended sediment loading for Detroit River from A.L.W. Kemp, R.L. Thomas, C.I. Dell and J.M. Jaquet, "Cultural Impact on the Geochemistry of Sediments inLake Erie", J. Fish Res. Board Can. 33:440-462 (1976).